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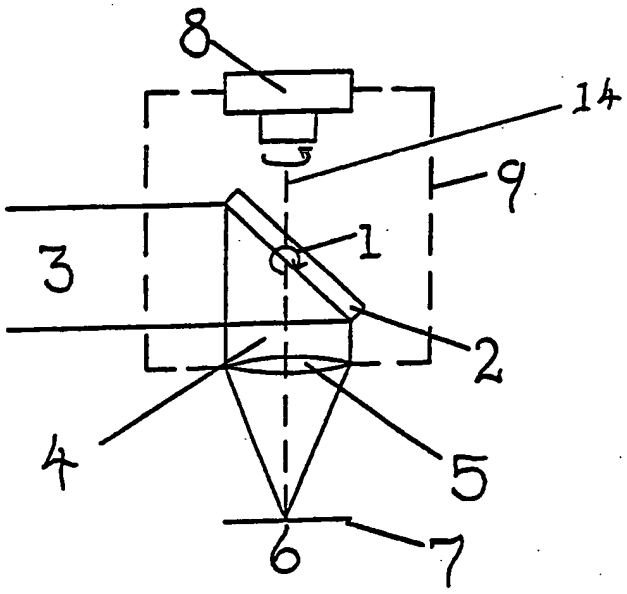
(54) Title: HIGH POWER, MULTI AXIS LASER BEAM CUTTER WITH IMAGE PROCESSING MONITOR



(57) Abstract

This invention relates to a vision controlled, multiple mirror/lens laser cutting head system in which the axis of rotation (1) of the output tracking mirror (2) provides the references for steering the laser beam (3) via the focussed output path (4) into its cutting tip (6) n a w rkpiece (7). The position of said focussed laser beam n workpiece (7) is viewed by a camera (8) positi ned behing the output mirror (2). The three mirrors (2), (10) and (11) and one lens (13) system can accurately steer powerful laser beams onto w rkpiece (7) and can rotate said laser beam around the central axis (14) f the system.

* See back f page

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High Power, Multi Axis Laser Beam Cutter with Image Processing Monitor

Field of the Invention

This invention relates to an optically controlled multiple mirror/ lens laser cutting head system consisting of a movable mirror to guide the laser beam onto the workpiece and a movable camera, attached to said movable mirror but with a rate of movement up to twice that of the said mirror around its axis of rotation, two fixed mirrors which allow said laser beam to be directed onto the said movable mirror, and a focussing lens which may be positioned either at the input end of the three mirror system or at its output end. The interaction of the focussed laser cutting beam with the said workpiece is optically monitored both to adjust the focus of said laser beam and its position relative to said workpiece, said focus being maintainable on the axis of rotation of said laser cutter system relative to said workpiece along more than three cutting axies. The invention is capable of directing very high power, large diameter laser beams onto the said workpiece and the said lenses are replaceable via the use of concave mirrors as the two fixed mirrors, when laser beams are used for which transmissive optics present problems, for example, carbon dioxide lasers. The invention can utilise large diameter laser beams with long focussing lengths allowing large lens to workpiece separation. The invention has applications in the industrial field where high precision laser machining of parts is required.

Summary of the Prior Art

Prior art laser beam cutters using focussed laser beams could not direct high power, large diameter beams onto the workpiece in such a manner that the optical monitoring of the said workpiece through the last laser beam directing mirror allowed the beam to be focussed along the axis of rotation of the laser beam cutting system, along more than three axis.

The present invention overcomes the defects of prior art laser beam cutters by allowing for large diameter, multikilowatt laser beams of any wavelength to be directed onto a workpiece on the axis of rotation of said system along more than three axis using a camera to monitor the relative movement between the said laser beam and the workpiece, said system processing of the said optical image in real time using either expert system or neural network computers, which in turn generate the electrical signals necessary to adjust the relative positions of the three mirrors and lens of the invention so as to keep the cutting tip of said high power laser beam precisely as required on the said workpiece being machined.

Background of the Invention

High precision laser beam machining of any workpiece demands a vision system which allows the operator to see the exact spot where the high power laser beam interacts with the workpiece, the parameters of the viewed focussed laser beam being adequate to precisely determine the dimensions of the cuts. Furthermore, when using high power laser beams, it is preferrable to work at comfortable distances between said workpieces and the output

aperture of the laser cutter.

In general, good machine vision necessitates mounting the cameras as near to the laser cutter's output aperture as possible and a good working distance can only be achieved with diffraction limited laser beams which also aid considerably in any measuring processes involving said laser beam.

In the present invention, the vision system is mounted onto the output mirror enabling the point of contact between the focussed laser beam and the workpiece to be monitored during the cutting sequence. The output mirror is one of three mirrors used to couple the laser output beam onto the workpiece in such a manner that the viewing direction is always along the axis of the projected, focussed laser beam.

The laser beam vision system of the invention allows the distance from the output aperture to be accurately measured from the observed spot size as the latter traverses said workpiece. By automatically adjusting the position of the three mirrors relative to each other, multi axis cutting, welding, hole drilling and case hardening of the workpiece can be achieved. As laser beam powers increase, their diameters tend to increase also and it becomes necessary to use a scaleable beam diameter laser beam cutting head.

The present invention is capable of being scaled to handle all laser beam powers that can be foreseen at this time. Futhermore, its vision system allows full use to be made of the material processing power of such laser beams.

Summary f the Inv ntion

It is an object of the invention to provide a three mirror beam steering laser cutting head which allows for the multi axis steering of a powerful laser beam onto a workpiece such that a camera mounted in the movable output mirror can observe the laser beam interaction with the workpiece along the laser beam axis in real time allowing for artificial neural computer control of the laser beam, cutting head and the workpiece, both separately and collectively as the case may be.

Another object of the invention is to monitor the distance from the output mirror of the invention to the workpiece by observing the diameter of the laser beam focus spot on said workpiece.

It is an object of the invention to provide accurately movable mirrors that can accommodate laser beams of large diameters and powers.

Another object of the invention is to direct the laser output beam along the axis of rotation of the cutting head.

It is an object of the invention to provide relative movement between the three mirrors so that the output laser beam can be steered along more than three axis relative to the workpiece.

Another object of the invention is to provide for a large working workpiece.

It is an object of the invention to provide high power laser beam cutting, drilling, welding and case hardening of the workpiece.

Brief Description of the Drawings

A better understanding of the invention will be obtained from the following considerations taken in conjunction with the accompanying drawings which are not meant to limit the scope of the invention in any way.

Figure 1 shows a schematic layout of the output portion of the invention with a digital camera viewing the workpiece through a movable mirror and a lens, said camera and lens being mounted on the same frame which rotates around the same axis as the said mirror but at up to twice its angular rate.

Figures 2 and 3 show the whole of the three mirror cutting head with the lens positioned on the laser beam input end of the invention rather than on its output end as in Figure 1. It will be noted that the mirrors are movable with respect to each and the system as a whole can rotate about a given axis at the same time maintaining the tip of the cutting beam on that axis.

Detailed Description of the Invention

In Figure 1, numeral 1 indicates the axis of rotation of the output laser mirror of the invention indicated by numeral 2. Numeral 3 indicates the laser beam traversing the invention whilst numeral 4 indicates the laser beam reflected off movable mirror 2, being focussed by the lens indicated by numeral 5 into a cutting tip indicated by numeral 6 on the workpiece indicated by numeral 7.

In Figure 1, numeral 8 indicates an electronic camera which views the workpiece 7 througn mirror 2 and lens 5. Numeral 9 indicates a common frame onto which both camera 8 and lens 5 are

mounted which also rotates around axis 1 be at up to twice the angular velocity of mirror 1 so that the tip 6 can be kept within the field of view. The electrical or optical output of camera 8 is fed into the computer image processing and control network (not shown) which can either take the form of an expert system or neural network computer, which in turn controls the movements of the components around axis 1 and the relative position of the optical components with respect to the structure of the invention as a whole and also their position relative to the said workpiece.

In Figure 2, the whole of the laser beam cutter system is shown with the off axis fixed mirror indicated by numeral 10 and the fixed mirror indicated by numeral 11, reflecting the incident laser beam indicated by numeral 12 which is focussed with the long focal length lens indicated by numeral 13. Numeral 14 indicates the axis of rotation of the systems as a whole.

In Figure 3, numeral 15 indicates the ability of the invention to direct the tip 6 of the laser cutting beam up and down the axis of rotation 14, with the image processed data fed into the control computers (not shown) from camera 8 generating the signals to adjust the position of said mirrors 2, 10 and 11 (tilt only) relative to each other so as to keep tip 6 on the rotational axis 15.

The invention has applications for materials processing of metals and non metals including ceramics and is capable of producing three dimensional models with high precision at high power, high cutting speeds.

Laser beam input 12 can be a single laser beam or a group of phase locked laser beams behaving as a single beam.

I claim,

1. A vision controlled, three mirror, single lens laser beam cutting head system consisting of:

a) A steerable output mirror which directs the focussed output laser beam onto a workpiece.

b) An input mirror which reflects the incoming focussed laser beam away from its incident propogation path onto a second mirror which is offset from the common axis of rotation of both the input and output mirrors and so positioned that it reflects the laser beam from the input mirror onto the output mirror.

c) A vision system which moves at twice the speed of the output mirror so as to observe the interaction of the output laser beam with the workpiece along the axis of said output beam.

2. A system as claimed in claim 1 where the focussing lens is positioned after the output mirror.

3. A system as claimed in claim 1 where all three mirrors of the invention are adjustable with respect to each other, all rotate about a common axis of rotation and can be adjusted to move the focus point of the focussed output beam up and down said axis of rotation.

4. A system as claimed in claim 1 where the measurement of the size of the focus spot of said laser output beam on said workpiece can be related to the distance of said output mirror from said work pi ce.

5. A system as claimed in claim 1 where the working distance

betw n th said output mirror and said workpiece is more than 50 cms providing ample space for the laser machining process.

6. A system as claimed in claim 1 where the diameters of the mirrors in the tracking head are scalable allowing laser beams of high power in the multikilowatts range to be used for materials processing.

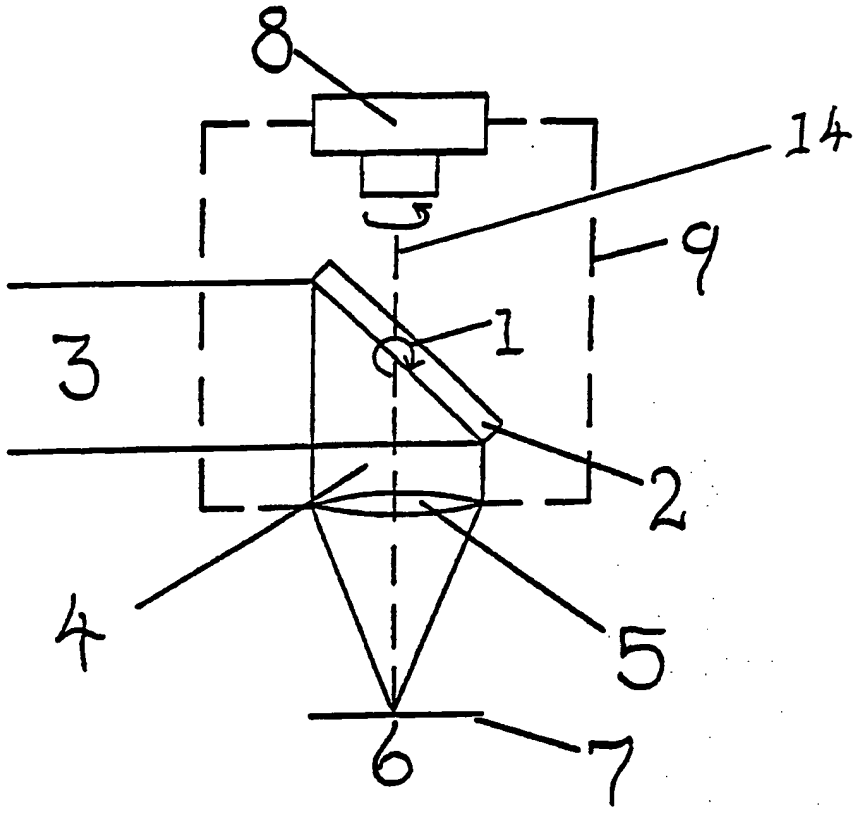

Figure 1

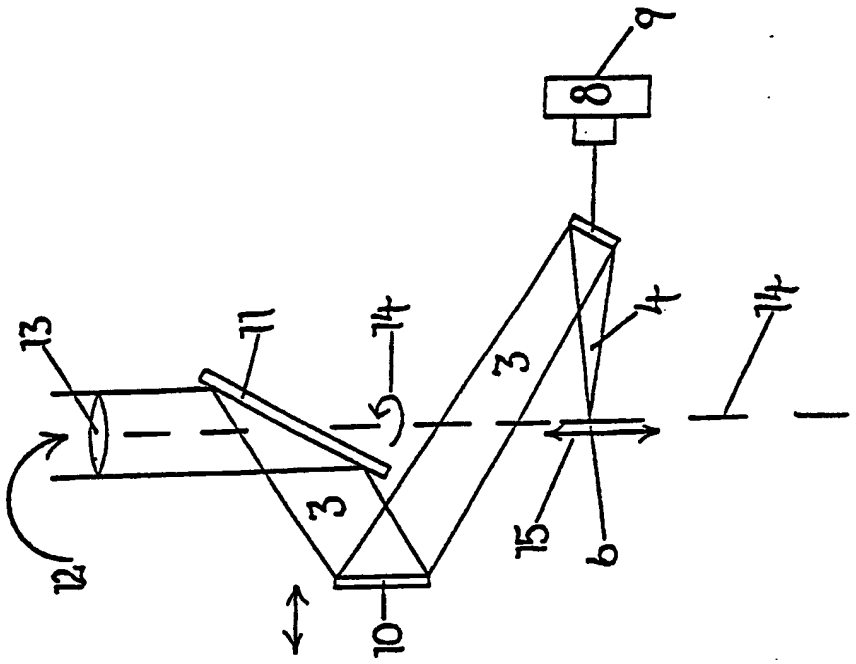

Figure 3

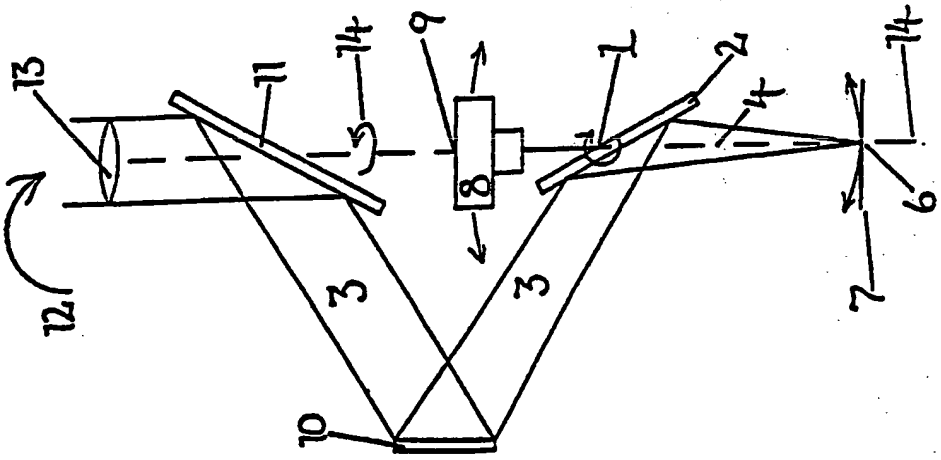

Figure 2

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to Int rnational Patent Classification (IPC) r to both National Classification and IPC

Int. Cl.[5] B23K 26/00, 26/02

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	B23K 26/00, 26/02

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
A	Derwent Abstract Accession no. 84-260449/42, Class P55, JP,A, 59-159291 (MITSUBISHI HEAVY IND KK) 8 September 1984 (08.09.84)	
A	WO,A, 87/06865 (IMAGE MICRO SYSTEMS, INC) 13 May 1987 (13.05.87)	
A	US,A, 4683493 (WESTINGHOUSE ELECTRIC CORP) 28 July 1987 (28.07.87)	
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
7 January 1991 (07.01.91)	10 January 1991
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	E. KNOCK